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CENTRE DE RECHERCHE SUR LES TRANSPORTS
UNIVERSITÉ DE MONTRÉAL
C.P. 6128, SUCCURSALE A,
MONTRÉAL
CANADA H3C 3J7

TÉLÉPHONE: (514) 343-7575
TÉLEX: (21) 05-561325
EMAIL: crt@crt.umontreal.ca
TÉLÉCOPIEUR (FAX): (514) 343-7121

91-05307/

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Land Use Factors in Home-Based Trip Purposes: A Geographical Analysis of Urban Transportation in Shanghai

by

Claude Comtois

Département de géographie, Université de Montréal, Centre d'études de l'Asie de l'Est et Centre de recherche sur les transports, Université de Montréal, C.P. 6128, succursale A, Montréal, Québec H3C 3J7 CANADA

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ABSTRACT

A wide variety of transportation modes are utilized in home-based trip purposes in Shanghai. It is the contention of this paper that land use factors, interacting with the home-based trips of each transportation mode, are the predominant causes of modal split. The paper is arranged in the following sequence. First, the Shanghai land use/transport context is presented. Second, the Shanghai urban transport system is examined. Third, an evaluation of the interrelationships between land use and urban transport is undertaken. Fourth, recent planning decisions in Shanghai with regards to the adoption of elements of an open market economy are evaluated. The paper demonstrates that land use discontinuities in commuting data reflect actual trip-making behavior. Four factors (distance, density, distribution and changes) combine to produce four transportation factors (very short trip length, land use pattern influences the transit system, modal split, business activities generate high bicycle movement). The paper concludes on possible recommendations to update transport survey activities.

Key words: Transport geography, modal split, land use, Shanghai.

RÉSUMÉ

Les modes de transport utilisés dans les déplacements quotidiens à Shanghai sont extrêmement variés. Cet article repose sur l'assertion que des facteurs d'utilisation du sol interagissent avec les déplacements quotidiens de chaque mode de transport et sont la principale cause de la division modale. Le manuscrit est agencé de la façon suivante. Premièrement, le contexte utilisation du sol/transport à Shanghai est présenté. Deuxièmement, le système de transport urbain à Shanghai est examiné. Troisièmement, une évaluation de l'interrelation entre l'utilisation du sol et les transports est entreprise. Quatrièmement, de récentes décisions de planification à Shanghai eu égard à l'adoption d'éléments d'une économie de marché sont évaluées. L'article démontre que des discontinuités d'utilisation du sol dans les données de trajet reflètent le comportement des déplacements. Quatre facteurs (distance, densité, distribution et changements) sont combinés pour produire quatre facteurs de transport (très court trajet, la distribution d'utilisation du sol influence le système de transport urbain, la division modale, les activités d'affaires engendrent beaucoup de mouvements par bicyclette). Le manuscrit conclut sur des recommandations de mise à jour des enquêtes de transport.

Mots-clés: Géographie des transports, division modale, utilisation du sol, Shanghai.

LAND USE FACTORS IN HOME-BASED TRIP PURPOSES:
A GEOGRAPHICAL ANALYSIS OF URBAN TRANSPORTATION IN SHANGHAI

Introduction

Of all the urban problems associated with Third World cities, traffic and transport problems are often a priority of the planning agenda of municipal governments. Problems of mobility are associated with the presence of a dual transport system where modern and traditional modes of transport coexist with a territorial structure shaped by the imperatives of a colonial economy. This is especially the case of Shanghai (Hamburg, 1989). A wide variety of transportation modes such as bicycles and transit buses are utilized in home-based trip purposes. What if one or more of those modes were related to the distribution of land uses? Then the trips via such modes would also be affected by land use changes, and data on those trips would exhibit some sort of territorial structure. The paper will attempt to provide geographical explanation of modal split in home-based trip purposes in Shanghai. The paper is arranged in the following sequence. First, the Shanghai land use/transport context is presented. It is used to describe the land use discontinuity in general. Second, the Shanghai urban transport system is examined. Traffic data are investigated to provide basic information for an understanding of movement in the city. Third, an evaluation of the interrelationships between land use and urban transport is undertaken. It is the contention of this paper that land use factors, interacting with the home-based trips of each transportation mode, are the predominant causes of modal split. Fourth, recent planning decisions in Shanghai with regards to the adoption of elements of an open market economy are evaluated with a view to examining their impact on the urban transport system and to presenting transport operation options.

Data to support the hypothesis are drawn primarily from the Shanghai Comprehensive Transportation Planning Institute. The paper will focus on the twelve urban districts of Shanghai. Data will also be drawn from recent field work in Shanghai.

Land use and transportation in Shanghai

Prior to 1949, Shanghai was divided into several territorial concessions affecting the location of urban land uses and the development of transport infrastructures (Antier, 1988). Manufacturing plants were found right at the city centre. Residential and industrial use intermingled with each other (Pannel, 1977). The Shanghai government was forced to make heavy investments in repair, replacement and reconstruction. All these investments were made in the public sector. The Chinese authorities adopted a deliberate policy of state ownership and control. In Shanghai, all lands were declared state-owned, although former owners of properties could still claim ownership to the structures built on them. Under this arrangement, land and the activities located on it have been separated to become two different entities. Besides, many businesses in the transport sector were abandoned. The government had no choice but to take them into public ownership. These municipal-owned companies enjoyed considerable protection and subsidies. Numerous municipal and national government organizations were thus created to secure state control. Given the importance of the metropolis, the Shanghai city planning institute was the first to undertake joint urban and transportation planning. Besides, transit management was recognized very early as one of the best in the country. Discussions concerning the territorial planning of the eastern side of the Huangpu (Pudong), adopted in 1990, started as early as 1947 (Pudong Development Office of Shanghai Municipality, 1990). The planning

scheme concerning the establishment of satellite towns around Shanghai was adopted in 1958. The Shanghai ring road construction plan started as early as 1965, while discussions on the possibilities of constructing a subway and erecting bridges over the Huangpu were already taking place. During the first three decades since 1949, the administrative system for land use decision and the movement of goods or people was structured according to a vertical administrative division. Shanghai was transformed into an industrial centre conforming to the principles of classlessness and urban uniformity. Self-sufficiency was praised (Shi, 1990). Every enterprise became the microcosm of the community, ringed by the residential complexes housing the factory's workers and their families with a few service centres dotted in between. Inter-industrial linkages between concerns were reduced to a minimum. Adding to the above is the difference between heavy and light industries land characteristics. Being China's major industrial centre, Shanghai is subject to the perennial policy of stressing heavy industry over light industry. Heavy industry is more land intensive than light industry. As a result, at the initial stage, Shanghai enterprises secured as much land as possible in view of future needs.

The implications for the internal organization of the city are apparent. First, as decisions concerning land use changes were directed from above, market forces cease to be an effective instrument of land use determination. The consequent urban land use pattern and rent has been arbitrary without reflecting urban rent closely related to the intensity of usage or centrality. Second, valuable land lay idle for long periods of time. Land use intensities were kept at artificially low levels even in places where the demand for land was high. Consequently, the need for the city to expand horizontally was inflated. The average trip length in Shanghai between 1950 and 1990 increased

from 3.5 km to 7.5 km. Third, local self-sufficiency resulted in a lack of investment in transportation. Shanghai was segmented into subregions with few interaction between them. Intra-urban transportation was thus reduced to short distances so that bicycles became the major means of civilian transport. Motorized transport was largely made up of trucks with some buses catering in principle to the need for long distance travel.

Urban transport in Shanghai

Infrastructure

The present metropolitan transport system dating back to 1949 was designed for a city of 100 km^2. In 1989, the Shanghai metropolitan area covered 6 340 square kilometers with a population of 12.7 million, with 7.7 million concentrated in the central city urban districts of 230 square kilometers. The street system of the centre city is a product of the European concessions that played a major role in the development of the city. The total length of urban streets is 1 674 km, constituting less than 10 percent of the land area. Road area per capita is less than 3 square meters. Streets have an average width of 13 meters. This narrowness renders a clear separation of motorized vehicle, bicycle and pedestrian traffic practically impossible, thus causing severe mixed flow between various types of traffic.

Public transit network

The emerging demand for passenger transport is one of the key issues of the transport system in Shanghai. After an upward trend since 1952, the average transit daily trips per capita appears to have stabilized since 1987 (Table

1). The travel demand in Shanghai has expanded at a rapid rate since 1949 due to both population growth and rising standard of living. But the decrease in the average number of transit daily ridership since 1985 suggests that the Shanghainese have adopted another means of transport to ensure their mobility. This in part results from the low density of the road transport network, as well as its limited capacity. Furthermore, table 1 indicates that the route length is increasing at a much faster rate than the number of public vehicles in service.

Bicycles

Table 2 reveals that the Shanghainese depend heavily on bicycles. The number of motorized vehicles has increased from 22 500 in 1970 to 176 200 in 1987. This is an average annual growth rate of 12.9 %. During the same period, the number of bicycles increased from 885 000 to 4 764 000 which represents an average annual growth rate of more than 10 %. But the road area increased at an average annual growth rate of 5 % only (Kojima, 1987). Roads are thus increasingly crowded. The Shanghai authorities have recognized that bicycles could move more people in a more economical way than any other option. Shanghai has invested in the low-cost production of bicycles and directed infrastructure improvements to non-motorized travel. Special bicycle corridors allowing five to six bicycles in width is very common in the municipality. Besides, guarded bicycle parking lots are plentiful as well as roadside services for repair and maintenance. The Shanghai government has used bicycles to relieve pressure in the overcrowded bus system by allowing commuters to have access to a bicycle. As a result, Shanghai has provided hundreds of thousands of people with a certain degree of individual mobility unparalleled in the developing world cities, while postponing heavy

TABLE 1

URBAN PUBLIC PASSENGER TRANSPORT PERFORMANCE IN SHANGHAI, 1952-1989

Year	Average daily trips per capita (pass/pop)	Average daily ridership (pass/ vehicle)	Vehicle density (vehicle/ km)
1952	0.13	1025	2.56
1957	0.25	1698	2.46
1965	0.37	1767	1.36
1970	0.42	2009	0.96
1975	0.54	2401	0.85
1980	0.81	2511	0.71
1985	1.13	2726	0.50
1986	1.15	2580	0.39
1987	1.22	2591	0.37
1988	1.22	2562	0.34
1989	1.18	2480	0.35

Source: Shanghai Statistical Yearbook 1990

TABLE 2

VEHICLE GROWTH IN SHANGHAI, 1970-1987

Year	Motor vehicles per capita	Bicycles per capita
1970	.002	.083
1975	.005	.120
1980	.007	.154
1985	.011	.303
1986	.013	.344
1987	.014	.381

investments in public transit. More insight may be gained by examining trip characteristics.

Trip characteristics

In 1986, 21 000 000 daily trips to work, shopping, university, school and other purposes were made in Shanghai by walking (38 %), bicycle (33 %), mass transit (26 %) and other vehicular modes (3 %). Table 3 shows that home-based and non-home-based account for 8.34 % and 91.66 % respectively of daily trip purposes. Besides, there appears to be a modal preference according to trip purpose. School, shops and other services are at walking distance from home. Shanghainese will use their bicycle to go to work, while university people will essentially use the mass transit system. Since daily trips to work represent 48.23 % of the total, more information may be gained by examining modal distribution of home to work travel time. First, there is a very clear difference between non-motorized and motorized transport in average trip time. Table 4 reveals that 70 % of journey-to-work purpose is provided by non-motorized transport with an average trip time of less than 21 minutes. Besides, the differences between groups are larger than disparities within groups. Indeed, the average travel time by bicycle is 2.3 times less than the average trip time by transit. Second, this sequence of four modes (walk, bicycle, transit, other) represents a progression of increasing trip length, average speed, range and extent of movement. All this suggests that inter land use linkages are realized through motorized linkages, thus underlining the use of non-motorized vehicles within land uses. This enhances isolated rather than agglomerated development.

TABLE 3

THE DISTRIBUTION OF TRIP PURPOSES IN SHANGHAI, 1986

(%)

Trip mode	Home to work	Home to shopping	Home to university	Home to school	Home to other	Non Home-based travel
Walk	28.2	74.6	14.9	77.7	40.5	28.3
Bicycle	41.4	14.8	22.6	14.8	26.2	31.5
Transit	27.6	9.7	61.5	6.8	30.2	27.7
Other	2.8	0.9	1.0	0.7	3.1	12.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number of trips	10 128 300	2 501 100	207 900	2 354 100	4 057 200	1 751 400

TABLE 4

HOME TO WORK TIME DISTRIBUTION BY MODE IN SHANGHAI, 1986

(%)

Time (minutes)	Walk	Bicycle	Transit	Other	Total
0-10	60.94	31.42	1.07	7.45	27.73
11-20	27.28	36.07	8.21	8.73	21.33
21-30	8.97	17.86	18.67	10.33	15.33
31-40	1.58	6.25	12.25	6.41	7.23
41-50	0.76	4.84	17.14	10.04	8.68
51-60	0.25	2.27	16.14	17.29	7.64
61-70	0.02	0.33	3.58	4.03	1.64
71-80	0.04	0.35	5.09	6.72	2.34
81-90	0.02	0.35	6.89	13.18	3.22
over 90	0.14	0.27	10.96	15.82	4.96
Total	100.00	100.01	100.00	100.00	100.01
Average trip time	12.62	20.84	47.02	55.42	31.28
Number of trips	2 856 181	4 193 116	2 795 411	283 592	10 128 300

Land use factors and modal split

The four specific modes appeared to have a strong potential for relating to the boundary of land use. The boundary of a land use is the lines that separate different land uses. Four land use factors are assumed to relate directly to the operation of transportation modes: distance, density, distribution and changes.

Distance

First, walking must for the most part be short since most people are sensitive to walking long distances. Dependent on unaided human effort, walking has a very small range. Therefore, many of these trips originating from residential areas would proceed within a given land use or terminate at the beginning of a contiguous land use. Second, cycling is less restrictive than walking. Still, in 1986, over four fifths of bicycle-to-work trips in Shanghai did not exceed 30 minutes. Since the average speed for bicycles in Shanghai is 12 km/hr, this would suggest journeys within rather than between urban districts. Third, mass transit systems are contained by certain land use types. Transit is line-haul in operation. In addition, transit systems rarely provide door-to-door service. Even when service is available, the trip may involve circuitous routing and several transfers. Breaks in transit lines, and other important shifts in transit operations, occur at major land use boundaries. Fourth, at the most restricted end of the transportation mode spectrum is the other motorized vehicle, which includes automobiles, vans, trucks, motorcycles and taxicabs. All land uses in Shanghai can be reached by this mode. Important limitations on commuting by this mode relate to the cost of purchase and operations, the need for a vehicle and the availability

of a driver.

Density

Shanghai suffers from traffic problems with public motor vehicles fighting bicycles for road space. City form influences the modal split of passenger movement. Innovative land use plans have clustered homes, shopping, school and work based on walking and cycling. Shanghai being a dense compact city, there is a continuity between traffic flow and economic activities. The central urban districts, therefore, have a high bicycle use content leading to congestion and high public transport unit costs. In low density areas, unit costs of public transport are low but users consume more mass transit because of the distances involved. Normally the spatial occupancy of a bicycle in Shanghai is 5.6 square meters. This occupancy falls to 2.5 square meters at rush hour. For each passenger in transit, there is one bicycle driver. Bicycle lines in Shanghai occupy parking space for buses and delivery trucks. Therefore, more road space is required with bicycle traffic than with mass transit. But Shanghai cannot lavish precious land for motor vehicles with the current severe land shortage, notably for housing purposes. Besides, bicycles use space more efficiently than transit while offering the convenience of individual mobility.

Distribution

Land use distribution can impact the nature of transit operations. Much of this effect traces back to the foreign settlements which were each granted exclusive jurisdiction on road construction. Typically, main roads marked the limits of each foreign settlement. Secondary roads were planned and

developed to extend as far as the limits of each territorial concession. In 1949, the transit route depended on the existing configuration of the street network while land uses in most cases were defined according to the already designed space. The land use distribution had a major impact on residential and workplace location.

Changes

The home-based work trip can be broken down into three components: residence, transport mode and workplace. In Shanghai, of these three, the transport mode is the easiest to change. A change of residence or a change of workplace is difficult. The decision to shift from commuting by bicycle to commuting by transit would require at most the purchase of a bicycle if one is not already owned by the household. In addition, the shift to bicycle can easily be reversed. The shift toward bicycles is a rational strategic alternative for any transit company confronted with weak land use interface and low mobility. In view of this, the shift since 1987 from commuting by transit to commuting by bicycle could reflect the difficulty in making the trip by transit due to increased congestion, but it could also reflect land use changes since the original trip in mass transit reflected the impact of land use boundaries on transit operations.

Evaluation in the context of recent reforms

The past situation of self-sufficiency has rendered the administrative planning of land use very difficult. Besides, the integration of Shanghai to the world economic market necessitates the organization of commodity flow and the improvement of circulation of goods and passengers. In 1978, the Shanghai

authorities were thus compelled to undertake two reforms: 1) the establishment of a distinction between state administrative organs and economic organizations and 2) the replacement of the vertical organization of economic activities by horizontal trade network linkages for procurement and distribution of goods (Hodder, 1990; Howard, 1990).

The course of these policies had several repercussions over the urban land use of Shanghai. First, the separation of business land uses from institutional uses generated a growth in the demand for office space. Besides, the shift in emphasis in industrial production from self-sufficiency to a commodity economy increased the demand for urban commercial space. Indeed, intensification of land use in central districts is often initiated and sustained by growth in the commercial sector. Second, commercialization implies corresponding changes in the urban transport system if the improvements in economic conditions resulting from economic reforms are to be sustained. Third, temporary urban residents generate a sizable amount of business trips that are not accounted for in Shanghai travel data.

Shanghai has undertaken many changes in its urban land uses. Most of the large-scale construction projects have direct or indirect connections with foreign trade or tourism (Smith, 1986). The distribution of these facilities is located along a corridor between Hongqiao airport and the Bund area. There are two reasons to justify this location: availability of land at the urban fringe and better accessibility through fluidity of circulation. With the completion of these projects the skyline of Shanghai has undergone substantial changes. The tallest buildings are joint venture hotels and office buildings. Although the traditional urban core is still characterized with mixed land uses, a distinctive land use pattern can be discerned. Individual shops,

restaurants, small factories and bazaar type markets encouraged by the system reform are emerging. Besides taking up the ground floors of original residential blocks, they occupy sidewalks and streets sections. Contrary to occurences in industrialized countries, the nature of emerging urban economic activities eventually determines the land use structure (Ochia, 1990). Besides, the distinction between home as a workplace and home as a residence is blurred. As a result, journey-to-work data are in many cases incomplete since part of daily travel needs is composed of business activities.

The enlargement and privatization of production result in increased interaction and interdependency between places and between enterprises. Transportation networks are needed to link the different parts of the city to form an integrated whole. Restrictions in private ownership of vehicles were thus gradually being lifted and the reserved field of public transit was opened to private enterprise. In March 1983 the Transportation Departments were explicitly called upon to allow individuals to buy vehicles for transportation purposes. In 1984 Chinese authorities began to sell imported vehicles to private persons. A new structure of circulation in various forms is coming into existence in the country. Transport is now run not only by the state-owned enterprises but also by collectives and individuals (Xinhua News Bulletin, 5 October 1985). Private concerns have become indispensable in the field of transportation. The creation of an informal sector is very important. This demonstrates the success of private firms in influencing movement at low cost.

Another easily observable feature in Shanghai owing to the system reform is the increasing number of temporary urban residents. The urban population average annual growth rate in Shanghai during 1978-1989 was 1.38 %. But only

a small part of this growth rate was due to natural increase. Indeed, the relaxation of control on rural-urban mobility has brought two types of migrants to Shanghai. The first group comprises the sent down youth who started to return to the cities in 1977. The other group mainly consists of temporary residents allowed to settle in the cities legally for six months. Usually their stay can be extended. On August 10, 1984, 590 000 individuals were residing in the city temporarily (Chang, 1987). In any case, these temporary residents have not been included in official urban population data. Another study estimates the number of temporary urban residents in Shanghai at over one million (Solinger, 1985). There is evidence that these temporary migrants are involved in the retail trade, services, repairs and crafts. But they have also created acute circulation problems since their occupational structure generates a significant amount of non-recorded business trips occurring irregularly. Emerging urban economic activities shape the land use structure. This suggests that an appreciable percentage of journey to work trips in Shanghai supports business activities.

Conclusion

Shanghai authorities are looking at territorial requirements for development very seriously because the present land use mix is inadequate for future growth, and practical capacity on routes has long been reached. In Shanghai, technical work to determine the land requirements both for the location of new economic activities and to answer various problems of traffic saturation was done thoroughly and well through the Pudong New Area Development Plan. The land use requirements and the necessary corridors are clearly identified, and a resultant land acquisition programme undertaken. Survey and land use planning work related to existing and possible future land uses was also

identified (Pratt and Pisarski, 1986; Pratt and Ross, 1986; Pisarski and Pratt, 1987; Wang, 1989). But references to the "official version" of the Plan assume a linear development that may not exist in practice and mask the difficulties faced by Shanghai policy-makers (Xu, 1990). This does not preclude organizations from understanding the objectives and purposes, to think seriously about their respective projects and their possible relationship to other projects, and have both the data and incentive to properly complete part of it. The problem is the intense difficulty related to the movement towards a more market-oriented economy. Under the policy of opening China to the world market in 1980, the potential burden of additional ground congestion is placed on Shanghai.

There is evidence of broad correlation between certain characteristics of the city and its transport level of supply. Transport policies have to be planned in the light of urban development objectives. First, there is a need to produce survey results that account for non-routine travel to complement the journey to work trips. This would enable to verify whether the importance of journey to work trips in planning transport is compatible with land use characteristics in Shanghai. A second pressing objective would be to relate the relationship between the number of trips generated as a function of difference between various types of economic activities. This would determine the influence of economic activities in the choice of travel itineraries by pedestrians, bicycle and mass transit users. A third objective should deal with the demand evaluation. This would reduce short and medium distance motorized urban travel needs.

Land use boundary discontinuities in commuting data reflect actual trip-making behavior. Four factors (distance, density, distribution and changes)

use pattern influences the transit system, modal split, business activities generate high bicycle movement).

Over the past decade, Shanghai has been the object of fundamental changes in the structure of its economy, the evolution of its transport network and the changing landscape of the inner city. This study has concentrated on explaining the land use and transport factors affecting Shanghai successes. This text has underlined inadequacies between transport and land use demands, and planning decisions. This paper suggests that interaction mechanisms need to be thoroughly researched to avoid creating long term problems through solving immediate problems concerning transport demand. Indeed, the results suggest that the comprehensive land use and transportation planning of Shanghai must first be formulated at a long term level.

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